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Fracture Analysis of Pipe of Tapered Thickness

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ABSTRACT

In this thesis, the clamped – free pipe tapered thickness effect on the deformations, stresses, stress intensity factors and frequencies is determined analytically for two cases. The pipe is conveying water. In the first case the pipe's wall thickness is constant at clamped end and it is changed at free end changes depending on different thickness ratio. In the second case the pipe's thickness at free end is constant and it is changed at clamped end at different thickness ratio. The pipe has a constant inner radius and length. The thickness ratios considered in this project are 0.6, 0.9 and 1. 3D models of the pipe are done in Creo 2.0. Static, Modal, Fracture analyses are done in Ansys 14.5.

I.INTRODUCTION

A pipe is a hollow cylinder or tubular section, normally but not certainly of circular cross-section, mainly utilized mainly for conveying substances that can flow — gases and liquids (fluids), powders, small solids masses and slurries. It can be utilized also for structural applications; solid pipe is less stiff / unit weight than hollow pipe.

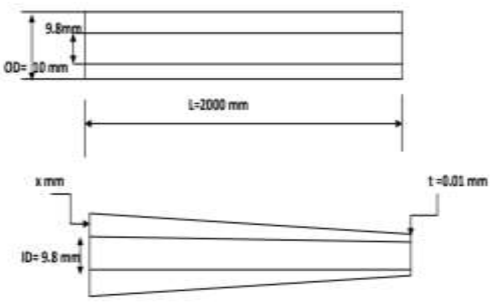

Fig 1: Introducing a Taper in the Pipe Carrying Fluid

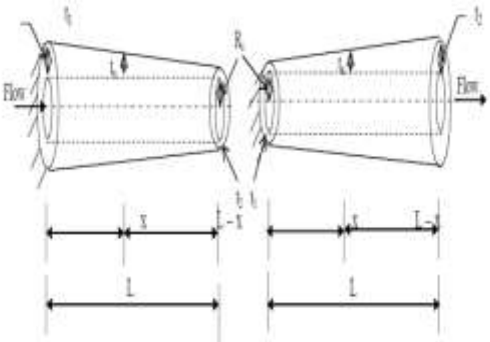

Fig (1-a) Cantilever pipe of tapered
Fig (1-b) Cantilever pipe of tapered Thickness $t2/t1\leq1$
Thickness $t\ 1/t\ 2\leq1$

II.LITERATURE SURVEY

Nawal H. Al Raheimy [1] studied the tapered thickness effect on the clamped – free pipe free transverse vibration which has cross section of uniform circular conveying water by employing Raighly – Ritz method for two cases, the 1st case involves a pipe having a constant wall thickness at clamped end and changing the thickness at free end according to the thickness ratio. In the 2nd case at free end thickness is constant whereas the clamped end thickness is changed by ratio. For uniform section of the pipe the natural frequency is decreased when the water velocity is increased from 0 to critical velocity.

Adnan N. Jameel [2] dealt with the straight pipe vibration & stability which is made of ASTM-214-71 mild steel, which conveys turbulent steady water with different boundary conditions and velocities. For investigation of residual stresses at pipe girth welds effect on the vibration characteristics & stability a new analytical model was. For evaluating pressure and velocity distributions in a single phase fluid flow a FE simulation was presented.

Jwege & Zahid[3] investigated the end conditions effect on the pipe vibration characteristics which is conveying fluid with various cross sections like (sudden enlargement & sudden contraction). Diverse end pipe supports (simply, flexible & rigid) were selected for investigation of the natural frequencies & their respective mode shapes. Also, investigation of some design parameters such as pipe length, diameter, pipe material effect and the fluid velocity effect were done.

III.3D MODELS OF PIPE WITH DIFFERENT THICKNESS RATIOS

The reference for the modelling is taken from the journal paper "Nawal H. Al Raheimy, Theoretical Study on Pipe of Tapered Thickness with an Internal Flow to Estimate Natural Frequency International Journal of Mechanical Engineering and Technology, 7(2), 2016, pp. 105–120" specified as [1] in References chapter.

Case 1:- Thickness Ratio --- $t_2/t_1 = 0.6$

Fig 2: - Extrude pipe with t_2/t_1 = 0.6

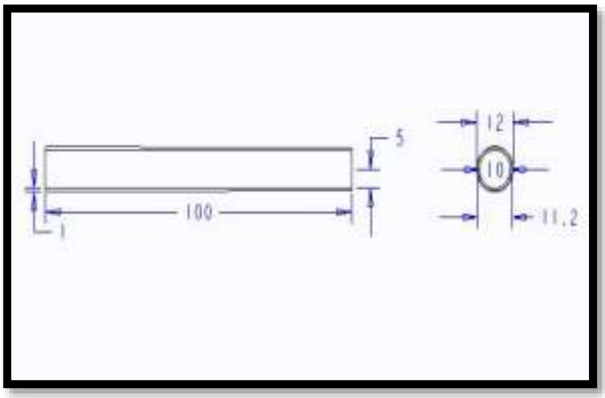

Fig 3: - 2d Drafting for pipe with t_2/t_1 = 0.6

IV.STATIC – MODEL ANALYSIS OF PIPE

THICKNESS RATIO $t_2/t_1 = 0.6$

MATERIAL – STEEL

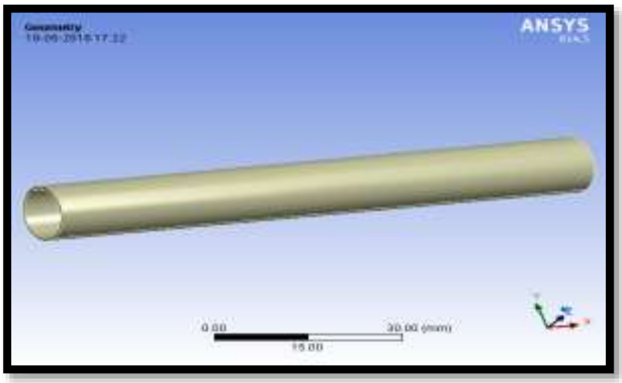

Fig 4: - Imported model of pipe with t_2/t_1 = 0.6

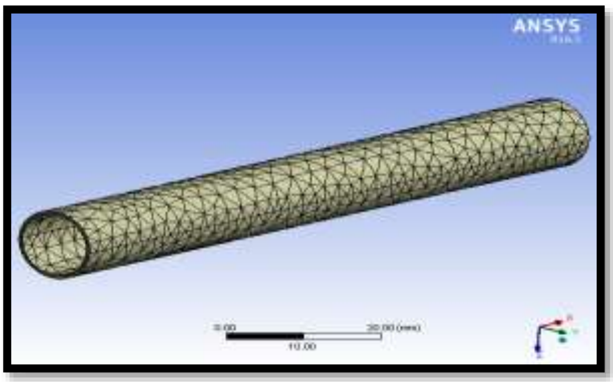

Fig 5: - Meshed of pipe with t_2/t_1 = 0.6

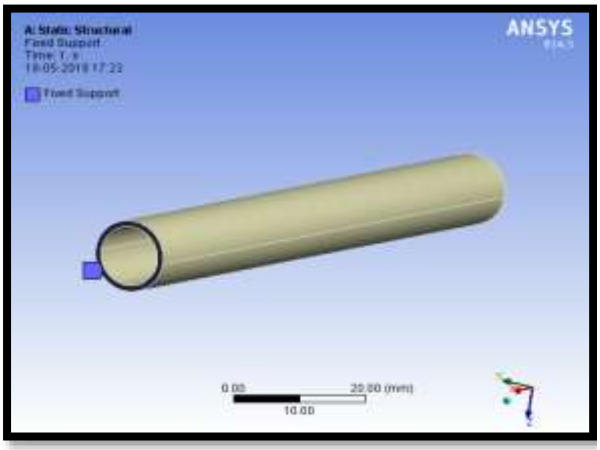

Fig 6: - Fixed support is applied at smaller end of pipe with $t_2/t_1 = 0.6$

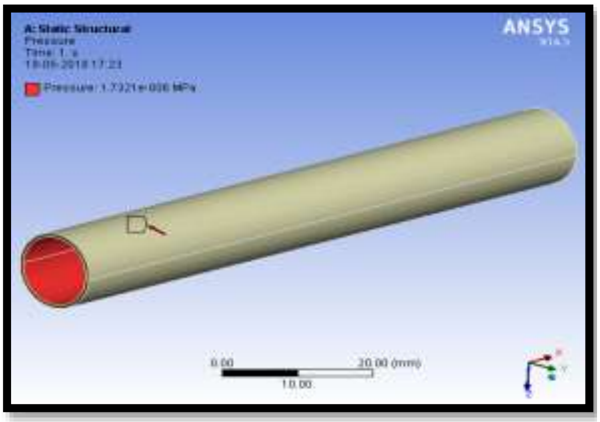

Fig 7: Pressure applied inside the pipe

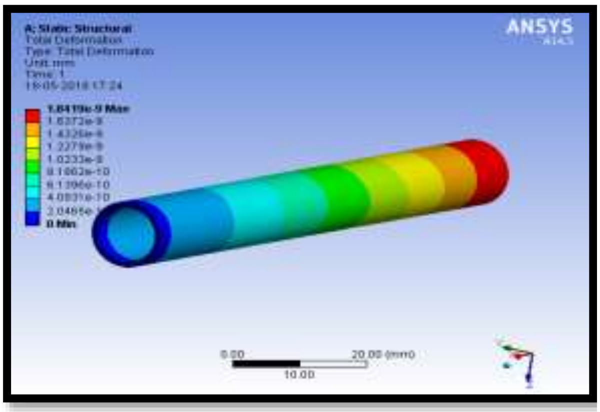

Fig 8: - Total deformation of pipe using Steel material with $t_2/t_1 = 0.6$

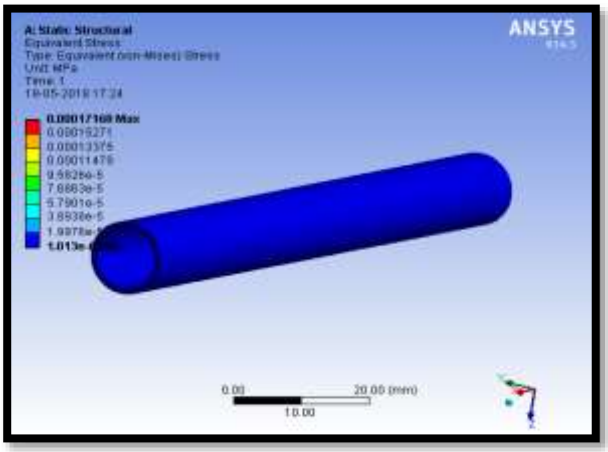

Fig 9: - Equivalent stress of pipe using Steel material with $t_2/t_1 = 0.6$

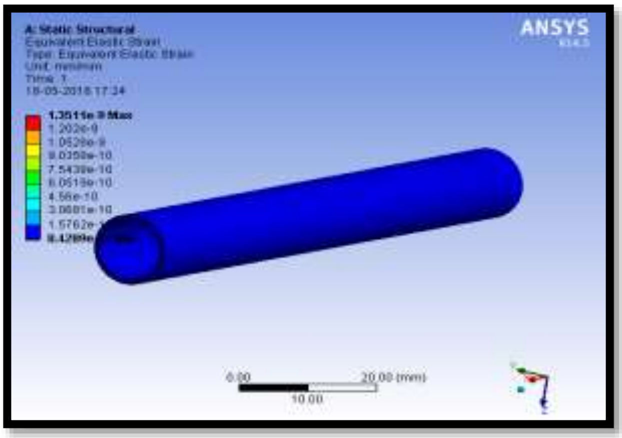

Fig 10: - Equivalent strain of pipe using Steel material with $t_2/t_1 = 0.6$

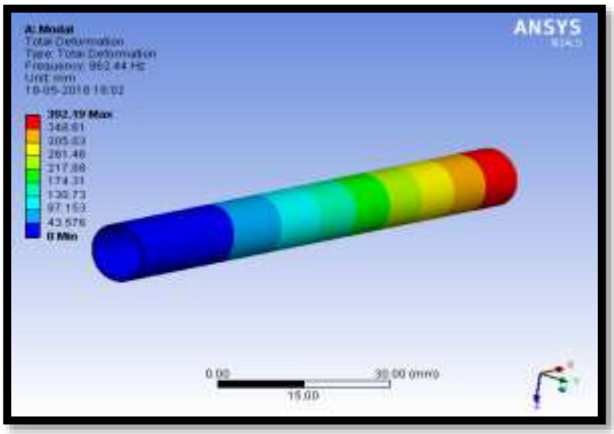

Fig 11: - Mode-1 of pipe using Steel material with $t_2/t_1 = 0.6$

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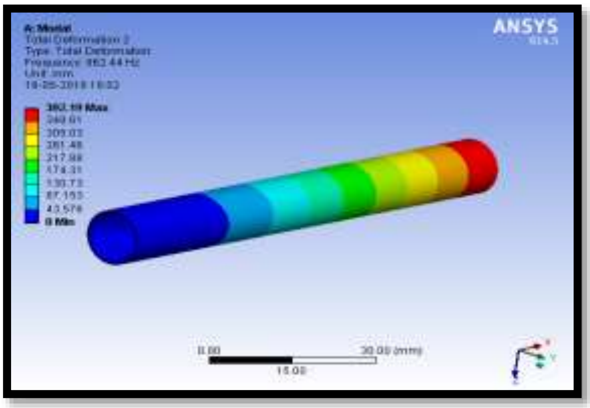


Fig 12: - Mode-2 of pipe using Steel material with t_2/t_1 = 0.6

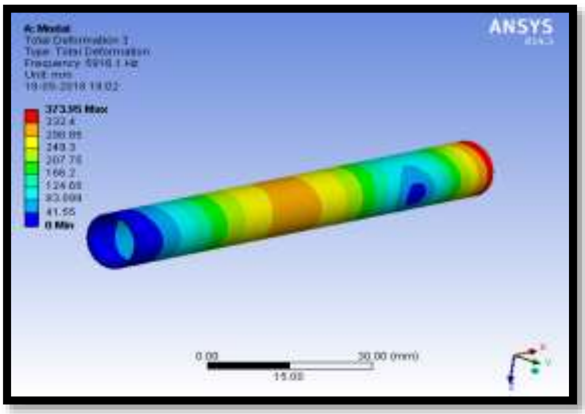


Fig 13: - Mode-3 of pipe using Steel material with t_2/t_1 = 0.6

V.FRACTURE ANALYSIS DUE TO CRACK ON PIPE

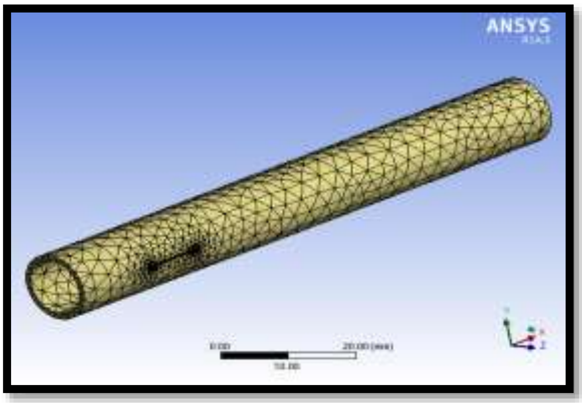
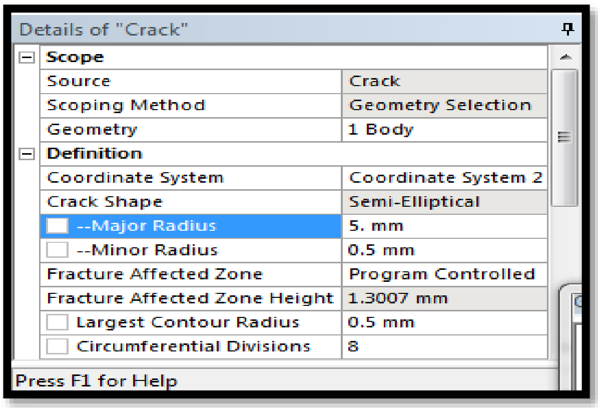


Fig 14: – Fracture meshed model of a pipe



Details of "Crack"

Scope	
Source	Crack
Scoping Method	Geometry Selection
Geometry	1 Body
Definition	
Coordinate System	Coordinate System 2
Crack Shape	Semi-Elliptical
--Major Radius	5. mm
--Minor Radius	0.5 mm
Fracture Affected Zone	Program Controlled
Fracture Affected Zone Height	1.3007 mm
Largest Contour Radius	0.5 mm
Circumferential Divisions	8

Press F1 for Help

Fig 15: – Crack details with pipe

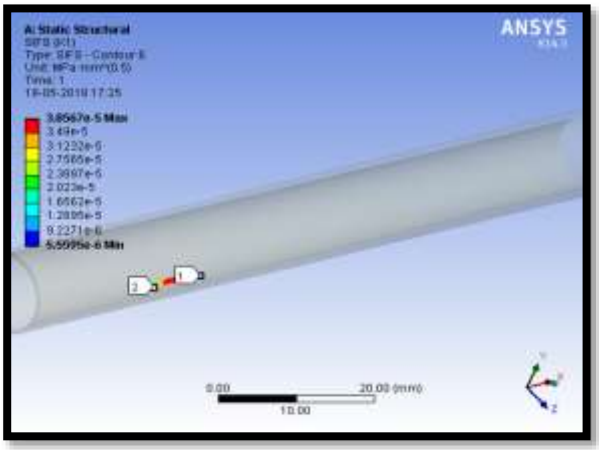


Fig 16: - Stress intensity factor in pipe using Steel with t_2/t_1 = 0.6

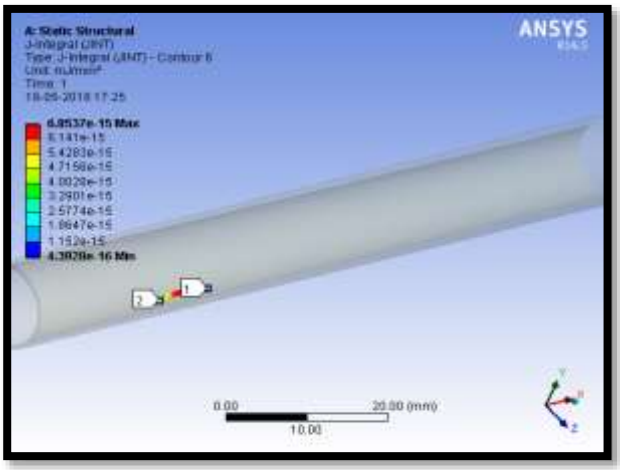
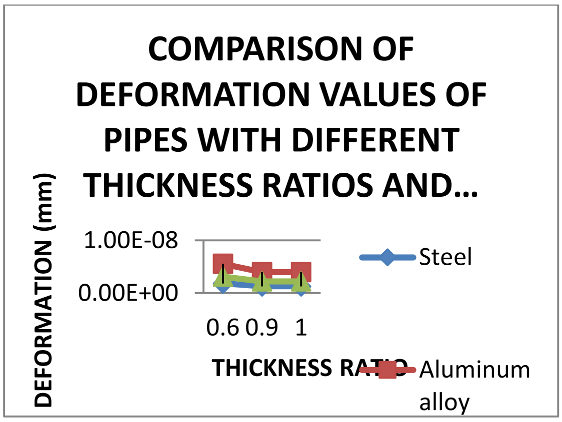
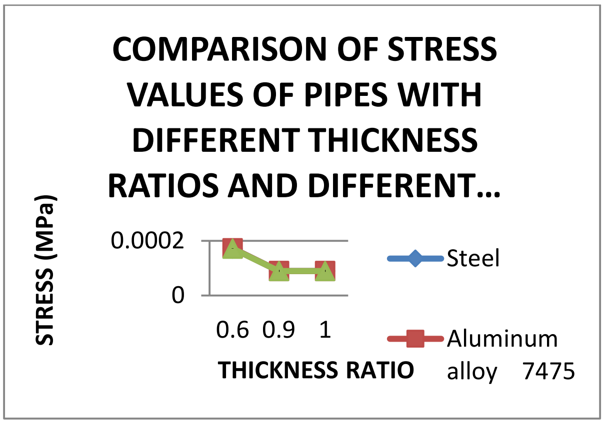
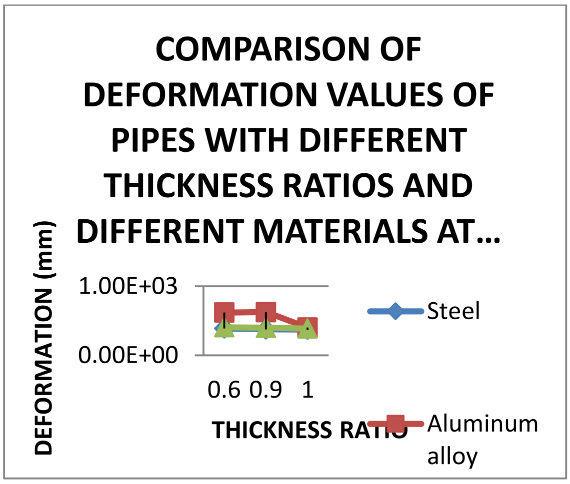


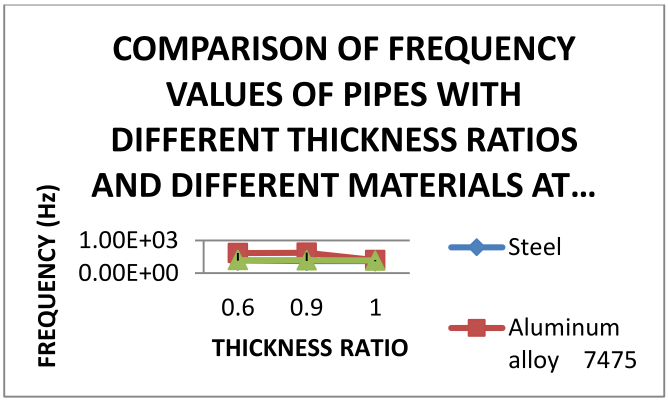
Fig 17: – J – Integral in pipe using Steel with t_2/t_1 = 0.6

VI.STATIC STRUCTURAL ANALYSIS

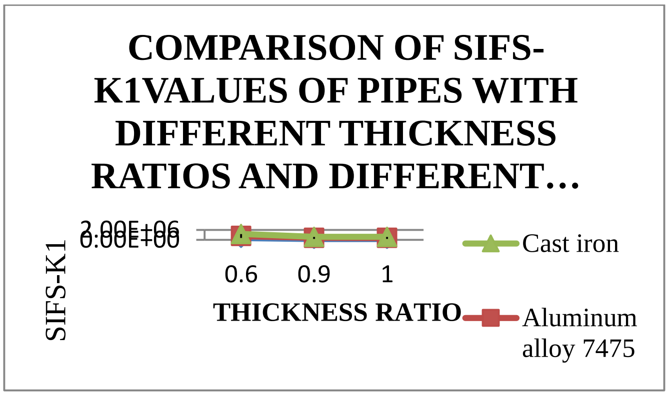


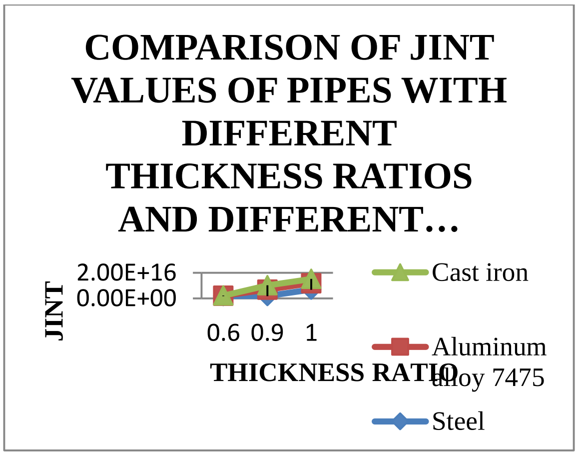






FRACTURE ANALYSIS





VII.CONCLUSION

By observing Static analysis results, the deformation is reducing by increasing the thickness ratio. The deformation values are less when Steel is used. The stress is reducing by increasing the thickness ratio.

The stress values are less when Steel is used. By observing Modal analysis results, the deformation is reducing by increasing the thickness ratio. The deformation values are less when Steel is used. The frequency is reducing by increasing the thickness ratio. The frequency values are less when Steel is used. By observing fracture analysis results, the stress intensity factors are reducing by increasing the thickness ratio and less when Steel is used. The J-Integral values are increasing by increasing the thickness ratio. The J-Integral value is more when Cast Iron is used.

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